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AUTHOR Rogers, Everette N.; Cook, Jerry L.

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ABSTRACT

The Training and Technology (TAT) Welding Technology Training Program is an intensive industrial training program conducted by Oak Ridge Associated Universities and Union Carbide Corporation designed to upgrade the skills of unemployed and underemployed individuals so they can command good jobs in industry. The document provides an introduction and an overview of the TAT welder training program. Described in detail are the curriculum, teaching methods, and philosophy of the training program. The program training takes 1,040 hours, or 6 months and 40 hours a week. It covers three major areas: welding lab, General Educational Development (GED)--High School Equivalency--and industrial behavior within an industrial setting. Trainees are introduced to gas welding and, on completion of the course, graduates are certifiable in plate and pipe electric arc welding. The document concludes with a two-page bibliography and appended material. (Author/BP)

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TAT WELDING TECHNOLOGY TRAINING PROGRAM

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Prepared By

Everette N. Rogers

and

Jerry L. Cook

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16. Abstracts

This describes the curriculum and teaching methods and philosophy of the Training and Technology Welding Technology Training Program. The training takes 1040 hours, 6 months and 40 hours a week. Graduates are certifiable in plate and pipe electric arc welding, and are introduced to gas welding techniques. Training is conducted in an industrial setting.

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TABLE OF CONTENTS

	Page
Preface	i
Introduction and Overview of TAT Welding Technology Course	1
Welder Training Curriculum	3
Welding Lab	6
General Educational Development (GED) - High School Equivalency	18
Industrial Behavior	20
Bibliography	
Appendices	

PREFACE

This describes the Training and Technology Welding Technology Training Program. TAT is an intensive industrial training program conducted by Oak Ridge Associated Universities and Union Carbide Corporation designed to upgrade the skills of unemployed and underemployed individuals so they can command good jobs in industry. In its nine years of operation, TAT has developed courses in response to industrial demand so as to minimize difficulty in placing graduates. Of the eleven courses developed in TAT's nine-year history, the Welding Training Course has been the most successful in terms of demand for the graduates. This derives from the growth in the welding occupation which is now occurring and has been going on for the past few years, from the difficulty and expense of training welders and of course, from the effectiveness of the curriculum and training techniques applied at TAT.

The Introduction and Overview section of this document is presumably of interest to persons generally responsible for or concerned about the training of welders. The major section, Welder Training Curriculum, describes the teaching of welding in more detail, and is hopefully of interest to persons directly involved or professionally interested in the teaching of welding.

INTRODUCTION AND OVERVIEW OF TAT WELDING TECHNOLOGY COURSE

The TAT welder training program is designed to give persons with no welding experience skills which command an entry level job in welding. This design principle is reflected in the curriculum in several important ways. It is the reason for the emphasis on electric arc welding over the traditional gas welding, because electric arc welding is in much more demand in industry today. It is also the reason for the emphasis on performance to specified standards of tasks typical of production situations, rather than construction of projects, which would be easier to administer.

The design principle also explains the 26 weeks duration of the Course, which is short by comparison to practically all others and also considering the range of skills to be acquired. Although short, the course is long enough to teach entry level skills. Generally, trainees learn enough to earn certification in plate welding (electric arc), and pipe welding (electric arc) and get a strong introduction to gas welding. In connection with this, it is worth noting an important distinction of the occupation of welding from other skills. There is an extensive network of certification requirements for the different methods and applications of welding. (Appendix A contains a list of organizations issuing certification codes.) Generally, each employer is responsible for seeing that each welder in his employment is certified according to appropriate specifications for the specific welding operations performed. Thus, each employer expects to do some skill upgrading and adjust assignments when new projects are begun. For this reason, the TAT welding program teaches the most frequently required welding skills which can be applied in the greatest variety of settings. More specialized skills are acquired in the course of the welder's employment.

The welding program, like the other TAT training programs, is also carefully designed to reflect as much as possible of the typical environment of a welder. This is accomplished by locating the program on an actual industrial site, having students trained by experienced welding supervisors, by using "line" equipment, and by treating trainees according to personnel policies typical of industrial organizations. Trainees do not resent these conditions, which are harsh by comparison to academic institutions. In this setting they understand the reasons for such policies and generally strive to fulfill them.

TAT programs, in welding and the other training areas, are administered cooperatively by Oak Ridge Associated Universities and Union Carbide Corporation, Nuclear Division. Most of the financial support for the program comes from Prime Sponsors under the Comprehensive Employment and Training Act of 1973.

This arrangement provides the program access (through Union Carbide) to the latest industrial techniques and practices, thus guaranteeing the relevance of the program. Instruction is performed primarily by craftsmen and industrial welding supervisors, who teach all the motor skills and the welding technology and welding blueprint elements. Academic instructors teach math and remedial education and GED classes, which account for only 15% or less of the trainee's time.

The TAT programs, and particularly the welder training program, have enjoyed notable success in placing graduates. Over the course of the past eight years, slightly better than 95% of the graduates have been placed and the average starting wages of the placed graduates have been higher than the general industrial average in the area. Welding graduates have fared particularly well, enjoying higher wages and often their pick of several good offers at graduation. Demand for welders has grown steadily in recent years, and the training of welders is generally involved and expensive. In this context, the TAT welder Training Program is especially valuable.

WELDER TRAINING CURRICULUM

The TAT welding curriculum was developed and has been implemented primarily by Union Carbide employees with years of welding, supervising and teaching experience. It is based on the occupational backgrounds in welding and consultation with numerous industrial and professional welding organizations rather than a formal job analysis or pre-existing curricula. Rather than relying on rigid task requirements, the program is flexible and adaptive to specific job needs of industries.

This curriculum document includes a description of the welder's work and an overview and detailed analysis of each of the training components. Each student is allowed to progress at his own level of capabilities. Each is required to practice until he can consistently meet the standards set up by the school. After trainees pass appropriate criteria, they are then set up and tested according to the requirements of American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section IX.

To bring the job description and specifications of the typical welder into focus, reference is made to the Dictionary of Occupational Titles (D.O.T.). The D.O.T. offers a general definition of the work tasks, the physical demands, the working conditions, the general educational development required, and the usual amount of training time for welders and numerous other trades and professions.

General Description of Welder Requirements and Working Conditions

The Dictionary of Occupational Titles presents the following brief review of the job and worker characteristics.

GAS WELDER - Welds metal parts together, as specified by layout, welding diagram, or work order, using gas welding equipment. The gas welder could be expected to:

1. Position parts in jigs, fixtures, on bench or floor, or clamps parts together along layout marks.
2. Identify specified torch, torch tip, filler rod, and flux, selecting them according to welding charts, or thickness or type of metal and specified bead.
3. Connect torch hoses to oxygen tanks and acetylene or other fuel tanks.
4. Turn handles to activate flow of gases, light torch, and adjust mixture to obtain desired flame.
5. Guide torch at proper angle along weld line, applying filler rod to molten area to supply needed metal to form weld.

General Description of Welder Requirements and Working Conditions (Cont.)

6. Examine weld for bead size and penetration.
7. Apply flux to workpiece in addition to filler rod.
8. Preheat workpiece in furnace or with torch to relieve internal strains caused by welding.
9. Repair broken or cracked metal objects, fill holes, or build up metal parts.
10. Perform brazing and flame-cutting operations.
11. Layout, position and tack weld workpieces.
12. Weld along vertical or overhead weld lines.
13. Chip or grind off excess weld, slag or splatter.
14. Clean or degrease parts, using wire brush, portable grinder or chemical bath.
15. Be required to pass tests as prescribed by his employer, such as Navy, Coast Guard, American Society of Mechanical Engineers, American Bureau of Ships, or American Welding Society.

ARC WELDER - Welds metal parts together as specified by layout, diagram, work order, or oral instructions, using electric arc welding equipment. The arc welder could be expected to:

1. Start power supply to produce electric current.
2. Adjust welding machine to desired amperage and/or voltage.
3. Connect cables from welding unit to workpiece to obtain desired polarity.
4. Obtain specified electrode or select electrode based on desired bead configuration, type of metal, and/or thickness of metal.
5. Strike arc and deposit metal from electrode to workpiece.
6. Guide electrode along weld line, maintaining length of arc and speed of movement to form specified depth of fusion and bead size.
7. Examine weld for size of bead and penetration.
8. Use carbon electrode for fusing and manually apply filler rod.
9. Clean or degrease workpiece, using wire brush, portable grinder, or chemical bath.
10. Repair broken or cracked parts, or manufacture new parts.
11. Chip or grind off excess weld, slag, or splatter.
12. Weld in all positions when required.
13. Preheat workpiece, using hand torch or heating furnace.
14. Position and clamp workpieces together or assemble them in jig or fixture.

General Description of Welder Requirements and Working Conditions (Cont.)

15. Tack assemblies together.

16. Flame-cut metal plates or structural shapes, using flame-cutting machines or hand torch and be designated welder-burner.

17. Be required to pass tests as prescribed by employer, such as Navy, Coast Guard, American Society of Mechanical Engineers, American Bureau of Ships, or American Welding Society.

Physical demands placed on a welder may generally be termed heavy since the welder may be expected to lift "100 lbs. maximum with frequent lifting and/or carrying of objects weighing up to 50 lbs." Welders often must adjust their body positons to allow effective welding of certain fabricated assemblies. This adjustment requires frequent stooping, kneeling, crouching, and/or crawling. The manipulation of welding equipment requires that the welder exercise his upper body frequently. This upper body work includes reaching "by extending the hands and arms in any direction, seizing, holding, grasping, turning, or otherwise working with the hand or hands." The ability to obtain impressions "through the eyes of shape size, distance, motion, color," and other factors is critical to the function of a welder.

Physical environment or working conditions of the typical welder may include both inside and outside work with extremes of temperature. Noise, fumes, odors, toxic conditions, dust, and poor ventilation are factors that may arise in certain work assignments of the welder.

General educational development and training time for welders are also included in the Dictionary of Occupational Titles. "Reasoning development and ability to follow instructions, and acquisition of tool knowledges, such as language and mathematical skills," have been listed under general education. Welding jobs generally fall into D.O.T. level six described as:

> Apply common sense understanding to carry out instructions furnished in written, oral or diagrammatic form. Deal with problems involving several concrete variables in or from standardized situations.

Typical mathematics development for a welder includes:

> Make arithmetic calculations involving fractions, decimals and percentages.

The Dictionary of Occupational Titles suggests that the amount of training time required to learn the techniques and information and to develop the skills needed "for average performance in a specific job-worker situation" is between one to two years.

Training Components

The TAT welding program is composed of six training components and a supportive component. The welding lab is the basic component. The welding lab is the basic component. This is "hands on" practice in welding, primarily in electric arc on both plate and pipe, and including about 25% practice in gas welding. Students are also trained in welding technology, welding mathmatics, welding blueprints, industrial behavior, and general education (both remedial and GED-oriented for students who do not hold high school degrees). The supportive component includes recruitment, placement, job development, and informal assistance with a variety of problems including financial difficulties, housing, transportation, and other problems which threaten to disrupt training.

Welding Lab

A large percentage (approximately 50%) of training time has been devoted to shielded metal electrode arc welding tasks since a majority of industrial welder needs lie in this area and mechanized welding machine operators can be trained on the job in a short period of time. Though the emphasis is on arc (shielded metal electrode) welding, the curriculum also includes activities in gas, gas tungsten arc, and gas metal arc welding. Trainees also receive an exposure to gas and arc cutting and gouging. The development of skill is the aim of welding lab, not the production of hobby projects. Trainees cut work blanks from plate and pipe stock then practice sequenced welding operations.

Instructional approaches in welding lab include direct teacher contact with demonstrations, practice sessions, performance tests, and feedback to the trainee. A typical student to teacher ratio is 12/1. The staff attempts to identify slower learners and to offer remedial assistance where possible. Often the instructors can suggest alternate manipulative techniques to help improve skill learning. High performance and high quality as recognized in industry are stressed by the instructors.

Trainee test welds are physically tested to assure the quality of the weldments and to prepare the trainee for employment certification tests. The TAT staff conduct weld tests in accordance with ASME Section IX, Guided Bend Test, Boiler Code. Trainees are not issued an ASME certificate because individual employers are required to test and certify employees for specific processes, materials, electrodes, etc., at the time of

employment. Areas of certification and the number of hours completed on specific welding areas are indicated on the TAT graduation diploma (see Appendix B).

The following list of specific learning objectives has been developed to illustrate the sequence of activities and to define in performance terms the welding tasks performed by the typical TAT trainee.

Shielded Metal Electrode - Approximate Total Lab Time: 479 hours

Plate Welding Practice. The basic material used in plate welding is low carbon steel plate stock 1/4-3/8" thick and 3/32-1/8" E6010 or comparable electrodes. Having set up and adjusted the equipment, each trainee is expected to perform the following tasks which the instructor will visually evaluate using workmanship samples as a criterion for performance. Each trainee is allowed to progress at his own rate.

1. Stike an arc and maintain that arc until the electrode has been consumed to a 2" stub.
2. Strike an arc and produce specified bead configurations.
3. Strike an arc and run stringer beads in the 1-G (flat position) to develop a pad.
4. Strike an arc and run stringer beads in the 2-G (horizontal) position to develop a pad.
5. Strike an arc and run weave and stringer beads in the 3-G (vertical) position to develop a pad.
6. Run stringer beads in the 4-G (overhead) position to develop a pad.
7. Make a fillet weld on a T-joint in the horizontal position.
8. Make a fillet weld on a T-joint in the vertical position.
9. Make a fillet weld on a T-joint in the overhead position.
10. Strike an arc and make a butt joint weld in the flat (1-G) position. Make a butt weld in the flat position on two pieces of 3/8" plate beveled to a 75° included angle with a 1/8" root face and spaced 1/8" apart.
11. Strike an arc and make a butt joint weld in the 2-G position. Make a butt weld in the horizontal position on two pieces of 3/8" plate beveled to a 75° included angle with a 1/8" root face and spaced 1/8" apart.
12. Strike an arc and make a butt joint weld in the 3-G position. Make a butt weld in the vertical position on two pieces of 3/8" plate beveled to a 75° included angle with a 1/8" root face and spaced 1/8" apart.
13. Strike an arc and make a butt joint weld in the 4-G position. Make a butt weld in the overhead position on two pieces of 3/8" plate beveled to a 75° included angle with a 1/8" root face and spaced 1/8" apart.

Plate Welding Certification. Having completed each of the preceding objectives and given proper equipment, trainees will perform the following tasks that conform to the certification requirements as listed in Section IX of the ASME Boiler Code:

1. Make a butt weld in the horizontal (2-G) position.
2. Make a butt joint weld in the vertical (3-G) position.
3. Make a butt weld in the overhead (4-G) position.

Test coupons will be prepared and destructive tested to the requirement of Section IX ASME Boiler and Pressure Vessel Code.

Pipe Welding Practice. Basic materials used in pipe welding include sections of 10" diameter schedule 40 pipe stock and 1/8-5/32" E6010 or comparable electrodes. Having set up and adjusted the equipment, each trainee is expected to perform the following tasks which the instructor will visually evaluate using workmanship samples as a criterion for performance:

1. Set up and make a weld in the horizontal plane on two pieces of 10" schedule 40 pipe in vertical position (2-G) beveled to a 70° included angle and having a root face of 1/8". The coupons shall be spaced 1/8" apart and tacked at 90° intervals. (open butt joints)
2. Set up and make a weld in the horizontal plane on two pieces of 10" schedule 40 pipe in horizontal position (5-G) beveled to a 70° included angle and having a root face of 1/8". The coupons shall be spaced 1/8" apart and tacked at 90° intervals. (open butt joints)

Pipe Welding Certification. Having completed each of the preceding objectives and given proper equipment, trainees will perform the following tasks that conform to the certification requirements as listed in Section IX of the ASME Boiler Code.

All pipe sections shall be beveled to a 37 1/2° bevel and shall have a 1/8"±1/32" root face. Prior to welding, the pipe shall be set up and tacked to provide a 1/8" root opening. The destructive test and test requirements shall be as specified in Section IX of the ASME Boiler and Pressure Vessel Code.

1. Set up and weld two pieces of 10" diameter schedule 40 pipe in the horizontal (2-G) position.
2. Set up and weld two pieces of 10" diameter schedule 40 pipe in the vertical (5-G) position.

Gas Welding Tasks - Approximate Total Lab Time: 200 hours

Trainees work on a rotational schedule in the gas welding lab for approximately 200 hours concurrently with arc welding lab.

At the appropriate time during gas welding lab, each trainee should be able to:

1. Set up equipment, light, adjust and manually operate a cutting torch to cut 3/8" mild steel stock with cutting lines acceptable for joining by arc and gas welding processes (freehand burning).
2. Having selected a welding tip and adjusted appropriate equipment for welding 1/4-3/8" thickness of base metal, carry a molten puddle in the flat position and add filler rod to produce a bead which will be visually inspected by the instructor using a workmanship sample as a criterion for evaluation
3. Having selected a tip and adjusted the flame, join two mild steel sheets using filler material. Acceptability will be judged by visual inspection using a workmanship sample.
4. Using semi-automatic gas cutting equipment, set up and adjust the equipment to produce sections of stock appropriate for joining by arc and gas welding methods.
5. Using similar or dissimilar metals of thicknesses 1/8", 1/4", and 3/8" and gas welding equipment, join those metals by brazing using silver filler alloys and/or by bronze welding using bronze filler alloys. Acceptability will be judged by a visual comparison with workmanship sample.

The trainee is not expected to be able to pass a certification test in gas welding. He is expected to have the knowledge of gas welding to do heating, burning or cutting, bending, brazing, and a limited amount of welding.

Specialized Welding Tasks - Approximate Total Lab Time: Variable

Having completed each objective outlined in the arc and gas welding program, trainees may have their curriculum varied to conform to desires of their prospective employers. The following objectives are general and variable depending on trainee knowledge, progress and completion times and employers' suggestions for specialization.

1. The above average trainee could be expected to spend 160 hours practicing with gas tungsten arc equipment. Welds would be performed in the flat, horizontal, vertical, and overhead positions on low carbon steel, aluminum and stainless alloy 1/8-1" thick and subjected to a visual inspection using workmanship samples as a criterion for acceptance. The exceptional trainee could be certified on various gas tungsten arc welds.

Specialized Welding Tasks (Cont.)

2. Trainees may receive approximately 140 hours of practice time in gas metal arc welding. Gas metal arc welding is performed on carbon steel, aluminum, and stainless alloy 1/4-1" thick using semi-automatic wire feed equipment. Trainees would be expected to set up, select proper wire size, trouble shoot equipment, and practice various welds using this process.
3. The average trainee could be expected to spend approximately 8-10 hours using arc air equipment to burn and gouge 1/4-1" metal stock.
4. Trainees practice approximately 100 hours using different kinds and sizes of electrodes (low hydrogen) (large diameter for fillet welds) (different alloys) on both plate and pipe.

Welding Technology

Text: Welding Skills and Practices by Giachino, Weeks and Brune. American Technical Society.

Workbook: Study Guide for Welding Skills and Practices by Masterton. American Technical Society.

Approximate Total Class Time: 3 hr./wk. x 13 weeks = 39 hours (outside assignments are given)

Welding technology classes provide technical information regarding the materials, methods, processes and equipment of welding. A large part of the welding technology instruction occurs in the classroom situation using Welding Skills and Practices as a general text and reference resource. Publications of Union Carbide Corporation, Y-12 Plant, and American Society of Mechanical Engineers provide alternate instructional resources (see Bibliography and Appendix). Topics covered in class sessions are demonstrated and reviewed when possible in the laboratory area by certified welding instructors.

Introduction to Welding Technology (11 hours)

Specific Objectives - At the appropriate time in the course, each trainee should be able to:

1. Define the welding process in two sentences or less.
2. Describe five basic welding processes as illustrated in class presentations.
3. Identify the following arc welding equipment or illustrations of the following equipment: power source, helmet, gloves, apron, electrode holder, cleaning tools, cable, ground clamp and electrode.

Introduction to Welding Technology (Cont.)

4. Identify the following oxy-acetylene equipment or illustrations of the following equipment: oxygen cylinder, acetylene cylinder, welding torch tip, regulators, hose, spark lighter, goggles and protective clothing.

5. List and demonstrate by performance in the lab five safety precautions in the set-up and operation of an arc welding machine.

6. List and demonstrate by performance in the lab five safety precautions in the set-up and operation of an oxy-acetylene welding rig.

7. List and illustrate two methods used to strike an arc when welding with shielded metal electrodes (tapping and scratching).

8. Describe a general rule for determining the approximate arc length for shielded metal arc welding.

9. Describe the procedure to follow in the event the electrode becomes welded to the base plate.

10. List and describe four factors that influence the penetration and quality of an arc weld.

11. Given a pictorial illustration of various improperly formed arc welding beads, identify the typical cause of the poor quality, such as speed, current intensity, and voltage.

12. Sketch an illustration of undercutting and overlap of arc welding beads and list typical causes of each condition.

13. Describe the importance of cleaning a weld before additional layers of beads are applied as described.

14. Illustrate by a sketch three weaving patterns typically used by arc welders as described.

15. Define padding in one sentence.

16. Illustrate by a sketch the typical oxy-acetylene torch movements of rotation and progression used in welding.

Welding Technology - Metallurgy (6 hours)

At the appropriate time in the course each trainee should be able to:

1. List two reasons why a welder should be familiar with basic metallurgy.

2. Describe each of the following mechanical properties of metal in two sentences or less: stress, strain, elasticity, tensile strength, compressive strength, bending strength, shear strength, fatigue strength, impact strength, ductility and hardness.

3. Describe the classifications of carbon steels according to percent composition, effect on mechanical properties, and spark test characteristics.

Welding Technology - Metallurgy (Cont.)

4. Define the term alloy steel and list four typical alloying elements used to alter the mechanical properties of steel.
5. List the associations represented by the following symbols: SAE, AISI.
6. Describe the effects of heat on the grain structure of steel as it is raised through the critical temperature to the melting point.
7. Given a list of metal treating procedures, identify each of those procedures by labeling as annealing, normalizing, stress relieving, peening, hardening, or case hardening.
8. Given descriptions of typical weld defects, identify the name of the defect and list procedures used to minimize the defect (defects will include grain growth, blowholes, inclusions, segregation, porosity).
9. List eight ways to control residual stresses in welded metal sections.
10. Given a list of 15 points to reduce distortion caused by expansion and contraction during welding, identify which of those points are true and which are false.

Welding Technology - Machines and Accessories (4 hours)

1. List the two typical input voltages used in current welding machines.
2. Define alternating and direct current in one sentence each.
3. Define conductor and electrical circuit and illustrate both by sketching an example of a simple electrical circuit.
4. Define ampere and discuss the effects of current intensity on shielded metal arc welding.
5. Discuss the application of reverse polarity direct current on overhead arc welding tasks.
6. List three types of power sources available for current welding tasks.

Welding Technology - Selecting the Electrode (7 hours)

1. List five of the main groups of shielded metal arc welding electrodes as described by text.
2. Given a list of eight possible functions of electrode coatings, identify five correct functions as listed in the welding textbook.
3. Given specific symbols used to identify welding electrode characteristics, identify the type electrode, the minimum tensile strength, the possible welding positions, and special characteristics of the electrode.

Welding Technology - Selecting the Electrode (Cont.)

4. List seven factors that must be considered when selecting an electrode for shielded metal arc welding.

5. Having studied the characteristics of mild steel electrodes and discussed specific applications in class, select an optimum electrode for operations described by the welding technology instructor.

Joints and Positions of Shielded Metal Arc Welding (5 hours)

1. Given illustrations of welding joints, identify each as: lap weld, T-joint, outside corner, closed joint butt, open joint butt, or vee joint butt weld.

2. List and describe four positions in which welding is carried out. The descriptions should include the position of the base metals and the relative movement of the electrode.

Welding Inspection Techniques (3 hours)

Having studied the textbook and discussed weld inspection, each trainee should be able to:

1. List a minimum of two applications and two limitations for visual inspection, destructive testing, and non-destructive testing.

2. Describe the tensile testing process by sketching the shape of a tensile specimen and listing the steps involved in recording the effects of load on the specimen.

3. Evaluate welded specimens by setting up equipment and conducting root-bend and face-bend tests using a guided-bend tester.

4. Define impact testing.

5. Identify illustrations of each of the following testing devices: magnetic particle equipment, radiographic inspection equipment, ultrasonic testing equipment, hardness testing equipment.

6. Given radiographs of sound and unsound welds, trainees should be able to distinguish between the two and identify those radiographs containing slag inclusions, cracks, gas pockets and lack of penetration.

7. Describe the operating principles of ultrasonic testing by describing the equipment, test procedures and evaluation techniques.

Certification and Code Requirements (3 hours)

Having discussed codes, standards and specifications with the welding instructors, each trainee should be able to:

1. List two justifications for requiring controls in the use and application of welds.

2. Define in one sentence each: code, standard, specification, and rule.

Certification and Code Requirements (Cont.)

3. Describe the process whereby voluntary regulations prepared by engineering and technical societies become enforceable rules.
4. List a minimum of four societies and organizations that prepare welding methods and standards documents.
5. Describe the typical elements and procedures of a certification test that a newly hired welder would encounter.
6. Movies, slides and visual aids are used to show the different welding processes as well as inspection, lab techniques and steel making processes.

Arithmetic Review (18.5 hours)

1. Define and illustrate: arithmetic, number, denominant number, and abstract number.
2. Illustrate the Decimal-Number System by showing the place value of integers relative to the decimal from millions to hundred-thousandths.
3. Add and subtract whole numbers.
4. Point out key words and units essential to the solution of word problems.
5. Given measurements in inches and feet, convert all to a specified denominant measurement.
6. Multiply and divide whole numbers.
7. Define and illustrate: common fraction numerator, denominator, fraction line, proper fraction, improper fraction, mixed number, and complex fraction.
8. Change an improper fraction to a mixed number.
9. Change the denominator of a fraction to a specified number.
10. Reduce a fraction to lowest terms.
11. Find the lowest common denominator for a maximum of eight fractions.
12. Add and subtract common and mixed fractions and reduce to lowest terms.
13. Multiply and/or divide common and mixed fractions.
14. Given problems in the multiplication and division of fractions, cancel out common factors in the numerators and denominators.
15. Express half of a fraction or mixed number without written computation, by using the short-cut method as described by Van Leuven, General Trade Mathematics.
16. Define and illustrate a decimal fraction.

Arithmetic Review (18.5 hours)

17. Write a common fraction in decimal form by dividing the denominator into the numerator.
18. Add, subtract, multiply and divide decimal fractions.
19. Round off decimals according to rule.
20. Find the average of a maximum of ten quantities by finding their sum then dividing by the number of quantities.
21. Change a whole number, mixed number, or decimal fraction to a common fraction with a desired denominator.
22. Utilize a decimal equivalent chart to interchange fractions and decimals.
23. List from memory decimal equivalents equal to 1/64, 1/32, 1/16, 1/8, and 3/8.

Geometry: Introduction and Review (9 hours)

1. Given exercise sheets and rulers, measure the length of lines accurate to the nearest 1/32 of an inch.
2. Given illustrations of micrometer readings, identify the measurements accurate to the nearest thousandth.
3. Define and illustrate: circle, circumference, diameter and radius.
4. Given paper and straight edge, construct two intersecting straight lines and label the vertex.
5. List from memory the number of seconds per minute, the number of minutes per degree, and the number of degrees per circle.
6. Define and illustrate right angle and straight angle.
7. Given an angle, determine with a protractor the number of enclosed degrees accurate to the nearest degree.
8. Given the number of degrees of a desired angle, use a protractor to construct that angle accurate to (+) or (-) one degree.
9. Given the diameter of a circle, find the circumference.
10. Define and illustrate area.
11. Given length and width, find the area of a rectangle.
12. Define volume and explain its relationship to linear measurement.
13. Given the diameter or radius, find the area of a circle.
14. Given diameter and height, find the surface area and volume of a cylinder.
15. Given three dimensions of a rectangular solid, find its volume.
16. List the names of two systems of measurement (English versus Metric).
17. List two advantages and two disadvantages of converting to the metric system of measurement.

Introduction to Formulas (11.5 hours)

1. Define and illustrate: formula, literal numbers, equation, terms, and substitution.
2. Given a relationship such as voltage equals amperes multiplied by resistance, develop a formula showing that relation.
3. Solve a single step first degree equation by (a) subtraction, (b) addition, (c) division, and (d) multiplication.
4. Given a problem with a literal term, substitute a given numerical value and solve.
5. Define volt, ampere, ohm, and give their proper literal representations.
6. List and apply Ohm's Law to the solution of typical electrical circuit problems.
7. Define electrical power and work in three sentences of less.
8. List from memory and apply the formula used to find electrical power when volts, amps, and time are given.
9. Define power factor in two sentences or less.
10. Given the number of kilowatts, hours, and cost per kilowatt hour, find the total cost of electricity.
11. Given illustrations of a common electrical watt meter, read the meter accurate to the nearest kilowatt hour.

Blueprint Reading for Welders

At the appropriate time in the course, each trainee should be able to:

Basic Blueprint Reading (13 hours)

1. Given illustrations of object lines, hidden lines, center lines, extension lines, leaders, cutting plane lines, list the purpose of each.
2. Given a typical blueprint, identify object lines, hidden lines, center lines, extension and dimension lines, and leaders.
3. Illustrate with a sketch the location and alignment of the front, top, and right side views of a three view drawing.
4. Given a pictoral and a three view drawing of the same part, identify selected sides and edges on alternate views.
5. Describe in two sentences or less the purpose of blueprint notes and specifications.
6. List two important purposes of blueprint dimensions as listed by Bennett and Siy, Page 14.

Basic Blueprint Reading (Cont.)

7. Illustrate and label the following items by a simple sketch:
   a. angular dimension
   b. dimension of a chamfer and bevel
   c. conventional dimensioning and
   d. base line dimensioning.
8. Given a dimensioned thread drawing, identify the thread diameter, the number of threads per inch, and the form of the thread.
9. Distinguish between sheet and plate steel by describing the measurement systems used.
10. Given a decimal thickness for a sheet of iron or steel, convert that dimension to a U. S. Standard Gage by using appropriate tables.
11. Define in two sentences or less revolved section and auxiliary section.
12. Describe the purpose of conventional break lines.
13. Given typical blueprint abbreviations as they appear in Bennett and Siy, Page 56, write out in word form the meaning of ten selected abbreviations.

Welding Blueprint Reading (26 hours)

1. Sketch the basic weld symbol and show the significance of arrow side and other.
2. Define each of the following:
   a. full section
   b. half section
   c. assembly section
3. Describe in two sentences the purposes of detail prints.
4. List the elements that may be added to the basic weld symbol.
5. Describe in two sentences the method of making reference to a special weld on a blueprint.
6. List four categories of welding abbreviations.
7. Distinguish a welding abbreviation from other abgreviations.
8. Sketch a welding symbol which indicates fillet weld all-round.
9. Describe the two methods of determining the extent of a weld.
10. Identify from a given weld symbol the finish and contour indications for a weld.
11. Sketch the symbol for each type of groove weld.
12. Define in two sentences or less root penetration and root opening of a groove weld.

Welding Blueprint Reading (Cont.)

13. Sketch or identify the symbol for each of the following:
    a. backing or back
    b. melt-thru weld
    c. plug
    d. slot weld
14. Illustrate by a sketch the dimensioning of the angle of a weld bevel.
15. Given a dimensioned symbol for flange weld, identify the:
    a. radius
    b. height above tangency
    c. size of the flange.
16. List six elements which may be applied to arc-spot and resistance-spot weld symbols.
17. Given a dimensioned symbol for resistance-seam weld, identify size and length of the weld.
18. Given illustrations with dimensions for typical weld joints, draw the weld symbols for those joints.
19. Given the weld symbol for typical weld joints, sketch the welded joints and show dimensions.

General Educational Development (GED) - High School Equivalency

(Appendix C contains a list of publishers of GED and remedial educational materials.)

The American Council on Education has developed a GED test battery which includes the following five subject areas:

1. correctness and effectiveness of expression;
2. interpretation of reading materials in social studies;
3. interpretation of reading materials in the natural sciences;
4. interpretation of literary materials, and
5. general mathematical ability.

This GED test battery is administered by a delegated listing agency, an official GED center, under the auspices of the State Department of Education, but only the State Department of Education may issue the equivalency diploma. Each State Department of Education established the policies and procedures for an adult resident to earn a high school equivalency diploma on the basis of results on the GED tests.

The TAT GED program was established to provide trainees with an opportunity to receive a high school diploma.

The program helps trainees prepare for the General Education Development test by (1) diagnosing their educational deficiencies and (2) concentrating on overcoming those weaknesses. Since the trainees have various problems, the program is set up in laboratory fashion to allow for individualization. The individualization allows students to progress at their own rate and to concentrate on those subjects in which a deficiency exists.

An equivalency diploma, which is honored by industry, colleges, and the military, is awarded by the State Board of Education to trainees who achieve a specified score on the GED test.

Trainees without high school diploma are encouraged and guided in preparing for the GED test. Time required for preparation varies greatly. Study topics are listed.

English:

1. Sentence Structure
2. Usage - Grammar
3. Style and Clarity
4. Punctuation
5. Capitalization
6. Word Choice - e.g., Affect, Effect
   Principal, Principle

Math:

Addition, Subtraction, Multiplication, and Division (whole numbers, decimals, fractions, basic algebra, and basic geometry)

Literature

Social Studies

Science

Developmental Reading

The objective of the developmental reading program is to ensure that reading deficient trainees reach the reading level required to achieve vocational-training success. Trainees deficient in reading are identified by selection test scores and/or performance in classroom activities. This objective is met by (1) diagnosing their reading strengths and weaknesses and (2) from these findings, planning a corrective reading program to overcome the weaknesses and reinforce the strengths.

Developmental Reading (Cont.)

To accomplish the program goals, the reading-deficient trainees are placed in one of four ability groups based on diagnostic testing. The trainees are assisted in reaching a reading level that permits them to easily handle required reading materials in welding.

While the development and growth of reading skills is a life long process, the reading program helps to build a solid foundation of basic reading skills which permits future development. The skill and remedial education staff evaluate individual needs and weaknesses and establish appropriate training time arrangements. Study topics are listed.

Phonics:

1. Consonant Sounds
2. Vowel Sounds
3. Common Syllables
4. Diagraphs
5. Blends

Word Attack Skills:

1. Syllabication
2. Structural Analysis
3. Context Clues

Comprehension:

1. Vocabulary Development - Word Meaning
2. Sentence Meaning
3. Paragraph Meaning
4. Main Idea
5. Detail

Industrial Behavior

(Course Description)

Total Scheduled Time: 15 hrs.

Job-related behavior of trainees is as much a part of overall employability as the skill acquired in welder training. The industrial environment within which TAT operates greatly facilitates the transfer of industrial behavior patterns.

Located within the Y-12 Plant and using Union Carbide supervisors, foremen, and skilled craftsmen as instructors, TAT exposes trainees to industrial standards of job-related behavior as an integral part of training. Trainees are confronted immediately with an industrial viewpoint of tardiness,

absenteeism, work habits, etc. Demands are made slowly at first because trainees are in a learning situation, but in the later months an industrial type supervisor-employee relationship is firmly established. Trainees must function under training rules and regulations similar to those of the Y-12 Plant operations.

Although the major responsibility for industrial behavior education falls on the shoulders of the section supervisors and technical instructors, assistance is given by other TAT staff members and Y-12 Plant personnel. Seminars on such topics as safety, industrial hygiene, job interviewing, drug addiction, and labor unions are scheduled at appropriate points in the program. Safe working practices and industrial hygiene are stressed throughout the program, and special emphasis is given these topics early in the program. Y-12 Plant safety specialists are called on to lead seminars in this area. Local union representatives are invited in to discuss their orientation and role in modern industrial organizations. In the latter half of the program the emphasis turns to job development skills such as interviewing, test taking, application writing, and job evaluation.

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TEXTS:

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Giachino, J. W., William Weeks, and Elmer Brune. *Welding Skills and Practices.* Chicago: American Technical Society, 1971.

Masterton, Robert N. *Study Guide for Welding Skills and Practices.* Chicago: American Technical Society, 1971.

Van Leuven, Edwin P. *General Trade Mathematics.* New York: McGraw-Hill Book Co.

TECHNICAL AND INSTRUCTIONAL REFERENCES:

A.S.M.E. Standards, Philadelphia: American Society for Testing Materials, 1958.

Oxy-Acetylene Handbook. New York: Union Carbide Corp. Linde Division, 1960.

Welding Alcoa Aluminum. Pittsburgh: Aluminum Co. of America, 1967.

Welding Handbook. New York: American Welding Society, 1968.

Y-12 Engineering Standards. Oak Ridge, Tennessee: Union Carbide Corporation, Nuclear Division, 1965.

REFERENCES

Modern Arc Welding. Troy, Ohio: Hobart Trade School.

U. S. Department of Labor. *Dictionary of Occupational Titles: Volume I Definitions of Titles.* Washington: U. S. Government Printing Office, 1965.

U. S. Department of Labor. *Dictionary of Occupational Titles: Volume II Occupational Classification.* Washington: U. S. Government Printing Office, 1965.

U. S. Department of Labor. *Dictionary of Occupational Titles: A Supplement To.* Washington: U. S. Government Printing Office, 1966.

INSTRUCTIONAL FILMS: (see also AWS Film Directory, American Welding Society, Education Department, 345 East 47th Street, New York, New York 10017)

Modern Facilities for Heavy Metal Fabrication. Combustion Engineering, Inc., Windsor, Connecticut 06095

The Micro-Wire Welding. Hobart Brothers Company, Troy, Ohio 45373

Solving Metal Joining Problems Through Brazing. Handy & Harman, 850 Third Avenue, New York, New York 10022

Fundamentals of Silver Alloy Brazing. Rothacker, Inc., 241 West 17th Street, New York, New York 10011

This is Steel. Bethlehem Steel, Modern Talking Picture Service, Inc., 714 Spring Street, N.W., Atlanta, Georgia 30308

Aluminum Welding Mig and Tig. Reynolds Metals Company, 5004 West Clay Street, Richmond, Virginia 23218

The Dual Story. Advertising Manager, Industrial Equipment, National Cylinder Gas Division of Chemetron Corp., 840 North Michigan Avenue, Chicago, Illinois 60611

The Oxy-Acetylene Flame - Master of Metals. Motion Pictures, Bureau of Mines, 4800 Forbes Avenue, Pittsburgh, Pennsylvania 15213

Appendix A

ORGANIZATIONS ISSUING CODES, STANDARDS, SPECIFICATIONS AND OTHER DOCUMENTS REGARDING WELDING

Aerospace Material Specifications (AMS)
See: Society of Automotive Engineers

American Gas Association (AGA)
605 Third Avenue
New York, N. Y. 10017

American Insurance Association
See: Underwriters' Laboratories, Inc.

American Petroleum Institute (API)
1271 Avenue of the Americas
New York, N. Y. 10020

American Society of Mechanical Engineers (ASME)
United Engineering Center
345 East 47th Street
New York, N. Y. 10017

American Society for Testing and Materials (ASTM)
1916 Race Street
Philadelphia, Pa. 19103

American Standards Association (ASA)
See: United States of America Standards Institute

American Water Works Association (AWWA)
2 Park Avenue
New York, N. Y. 10016

American Welding Society (AWS)
Technical Department
United Engineering Center
345 East 47th Street
New York, N. Y. 10017

Bureau of Explosives
63 Vasey Street
New York, N. Y. 10007

Bureau of Public Roads, U. S. Department of Transportation
Matomic Building
Washington, D. C. 20235

Canadian Standards Association
235 Montreal Road
Ottawa 2, Ontario, Canada

Compressed Gas Association, Inc. (CGA)
500 Fifth Avenue
New York, N. Y. 10017

Factory Mutual Engineering Corporation
1151 Boston-Providence Turnpike
Norwood, Mass. 02062

Factory Mutual Laboratories (FM)
See: Factory Mutual Engineering Corporation

International Acetylene Association (IAA)
The IAA has been consolidated with the
Compressed Gas Association, Inc.
Address all requests to CGA

Interstate Commerce Commission (ICC)
12th Street and Constitution Avenue
Washington, D. C. 20423

National Certified Pipe Welding Bureau (NCPWB)
666 Third Avenue
New York, N. Y. 10017

Naval Supply Depot
5801 Tabor Avenue
Philadelphia, Pa. 19120

Society of Automotive Engineers (SAE)
485 Lexington Avenue
New York, N. Y. 10017

Underwriters' Laboratories, Inc.
P. O. Box 247
Northbrook, Ill. 60062

United States of America Standards Institute (USASI)
10 East 40th Street
New York, N. Y. 10016

TRAINING CERTIFICATION

IN WELDING TECHNOLOGY

This is to Certify that

_____

Attended and Received ____ Weeks of Instruction in Welding

at the Oak Ridge Y-12 Plant

SHIELDED METAL ARC (PLATE) POSITION:

2G _____

3G _____

4G _____

SHIELDED METAL ARC (PIPE) POSITION:

2G _____

5G _____

GAS TUNGSTEN ARC (PLATE) POSITION:

2G _____

3G _____

4G _____

GAS TUNGSTEN ARC (PIPE) POSITION:

2G _____

5G _____

_____
OAK RIDGE ASSOCIATED UNIVERSITIES

_____
DATE OF ISSUE

_____
OAK RIDGE Y-12 PLANT

_____
TRAINING SUPERVISOR

Training and Technology Project-Supported by the U.S. Atomic Energy Commission and U.S. Department of Labor

Appendix B

Appendix C

PUBLISHERS OF REMEDIAL EDUCATION AND GED MATERIALS

Allied Education Council
Distribution Center
P. O. Box 78
Galien, Michigan 49113

ARCO
219 Park Avenue S.
New York, N. Y. 10003

Barnell Loft, Ltd.
111 S. Center Avenue
Rockville Center, N. Y.

Bobbs-Merrill Company
4300 W. 62nd St.
Indianapolis, Indiana

Bureau of Publications
Teachers College
Columbia University
New York, N. Y. 10027

Basic Systems, Incorporated
880 Third Avenue
New York, N. Y. 10022

Cambridge Book Company
488 Madison Avenue
New York, N. Y. 10022

Craig Corporation
Education Division
3410 S. LaCienega Blvd.
Los Angeles, California 90015

The Continental Press, Inc.
367 S. Pasadena, California 91105

Educational Developmental Laboratories
75 Prospect, Huntington, N. Y. 11746

Encyclopedia Britannica Press
425 N. Michigan Avenue
Chicago, Illinois 60611

Electronic Futures Incorporated
Order from:
Rouser Company
208 W. Magnolia
Knoxville, Tenn.
Attention: Jim Hood

Educational Guidelines Co.
Oklahoma City, Oklahoma

Educators Publishing Service
Cambridge, Mass.

Follett Ed. Corp.
1010 Washington Blvd.
Chicago, Ill. 60607

Field Enterprises Inc.
Merchandise Mart Plaza
Chicago, Illinois 60654

Frank E. Richards Pub. Co., Inc.
324 First St.
Liverpool, N. Y. 13088

Globe Book Company
175 Fifth Avenue
New York, N. Y. 10010

G. C. Merriam Company

General Learning Corporation
753 Fairfield Avenue
Bridgeport, Connecticut 06604

Grolier Incorporated
575 Lexington Avenue
New York, N. Y.

Harcourt, Brace & Javonovitch
1372 Peachtree Street, N. E.
Atlanta, Georgia 30309

Houghton Mifflin Company
2 Park St.
Boston, Mass. 02107

Lyons & Carnahan Publishers
407 E. 25th Street
Chicago, Illinois 60616

McMillan
255 Ottley Drive, NE
Atlanta, Georgia 30324

McGraw-Hill
Manchester Road
Manchester, Missouri 63011

PLAN Incorporated
1307 West Markham
Little Rock, Arkansas 72201

Prentice-Hall, Inc.
Englewood Cliffs, N. J.

Readers' Digest Services, Inc.
Pleasantville, N. Y. 10570

Scott Foresman & Company
3145 Piedmont Road, NE
Atlanta, Georgia 30305

Science Research Associates
259 East Erie Street
Chicago, Illinois 60611

Steck Vaughn Company
P. O. Box 2028
Austin, Texas 78767

Time/Life Corporation

Westinghouse Learning Corp.
100 Park Avenue
New York, N. Y.

Ziff - Davis Publishing
One Park Avenue
New York, N. Y. 10016